Extended abstract No. 180

RECENT HISTORY OF A MODIFIED PEAT DOME, COASTAL RIAU, SUMATRA

John Bathgate, PT. RAPP PO Box 1080 Pekanbaru, Riau 28000, Indonesia
john_bathgate@aprilasia.com +628127570724, and Reddy Rachmady, RAPP

SUMMARY

Agricultural development of Indonesian peatland has come under scrutiny for the high levels of carbon emitted. Few data on baseline emissions prior to development exist. This study records landscape level changes in topography and forest cover that occurred over seven years preceding development. Data have come from high resolution digital aerial photos, forest sampling and from topographic leveling surveys. The raised peat landform studied here had become distorted by subsidence valleys within a decade of drainage being introduced from ditches dug to illegally extract logs. Changes in land surface levels and in forest cover measured over the pre-development period indicate that carbon emission from soil subsidence and forest biomass loss was in the order of magnitude of CO_2 25-30 t ha^{-1} yr^{-1}.

KEY WORDS: Peat dome, deforestation, carbon emissions, subsidence, forest biomass

INTRODUCTION

Clearing of 5 M ha of natural forest and mass immigrations of settlers have transformed Riau province from forest clad, sparsely populated and without infrastructure 40 years ago, to a dynamic agricultural economy today. The clearing now occurs on the peat soils covering 40% of Riau (Bathgate et al, 2011). Emissions of carbon from drained peat have raised calls that this type of development be halted (Verchot et al, 2010). In reality there are few if any alternative sources of income for many subsistence rural communities.

This paper describes changes that occurred to a 23,000 ha study area while it waited to be developed. The area is an outcrop to one of the larger peat domes that make up the Kampar Peninsular in coastal Riau. The process by which original forests in this setting are converted to agriculture is described by Bathgate et al (2011). The first step, selection logging, had little impact on the study area leaving it with forest cover still intact. Then from 1997 political upheaval triggered a period of unchecked illegal logging. To extract logs, a network of small drains connecting to the nearest river were excavated, used and abandoned. This paper attempts to quantify the landscape level impacts that followed.

MATERIAL AND METHODS

Remote Sensing

Loss of forest cover has been mapped on digital images from aerial photos taken in 2005 and 2009. Three cover types were recognized: *intact* where most large trees (>8 m crown diameter) remain; *degraded* where 50% or more of large trees had gone; and *non-forest* where >50% of cover is non woody. Logging drain locations were also digitized.

Forest Vegetation Survey

In 2004 the least modified natural forest was sampled with 22 bounded plots, size 100 x 20 m. Stems were tallied by species in 20 cm diameter classes, peat bored for depth and nature of substrate, canopy height and GPS locations taken. In 2011 15 plots located in set-asides from development were re-measured. No new logging had occurred on the plots after 2004. Small number of plots precluded statistical analysis. Stem volume scaled up from the sample plots (m^3 ha^{-1}) has been converted to total biomass CO_2 (t ha^{-1}) by a factor of 1.1 (1.5 to include all biomass, 0.5 basic density, 0.4 carbon content, 3.67 CO_2).

Topographic Survey

The area was surveyed for ground levels in 2003. In 2010 the sub-area being opened was resurveyed. Surveys used two independent sightings with a tripod-mounted instrument, taken at each station to the adjacent ones about 60 m distant. This was repeated along lines spaced 2 km apart, joined by cross lines at 4 km intervals. Closure error in elevation was 0.03 m km^{-1}. Data were processed to digital elevation model (DEM) then converted to a 3-D solid to analyze landscape surface changes 2003-10. Soil carbon emission has been derived from the soil volume loss by applying the soil factors of 0.07 for bulk density as was sampled from lowest water table, 0.54 for carbon content, and 0.50-0.70 range for the oxidation portion of subsidence, after Hatano et al (2010)

RESULTS

Vegetation Change

Figure 1 shows the 2009 forest cover. Landscape scale changes in the mapped vegetation cover types are summarized in Table 1a. Intact forest had shrunk 1,200 ha since 2005.

At sample plot scale, forest and biomass change from 2004-11 is summarized in Table 1b. Table 2 summarizes sampled forest change and its possible causes. Plots that did not lose biomass between measurements were located in intact forest >500 m from logged canopy gaps. Intact forest plots located <200 m from previously logged canopy gaps had fewer live stems in 2011 than in 2004, more dead and fallen stems. Intact forest plots located on the margin of canopy gaps had lost trees to gap edge effects over the period, although remaining *intact* by our definition. Plots that sampled logged gaps in 2004 had by 2011 lost half or more biomass to gap expansion and collapse of remaining large trees, associated in one plot with soil drainage and in another with localized ground fire.

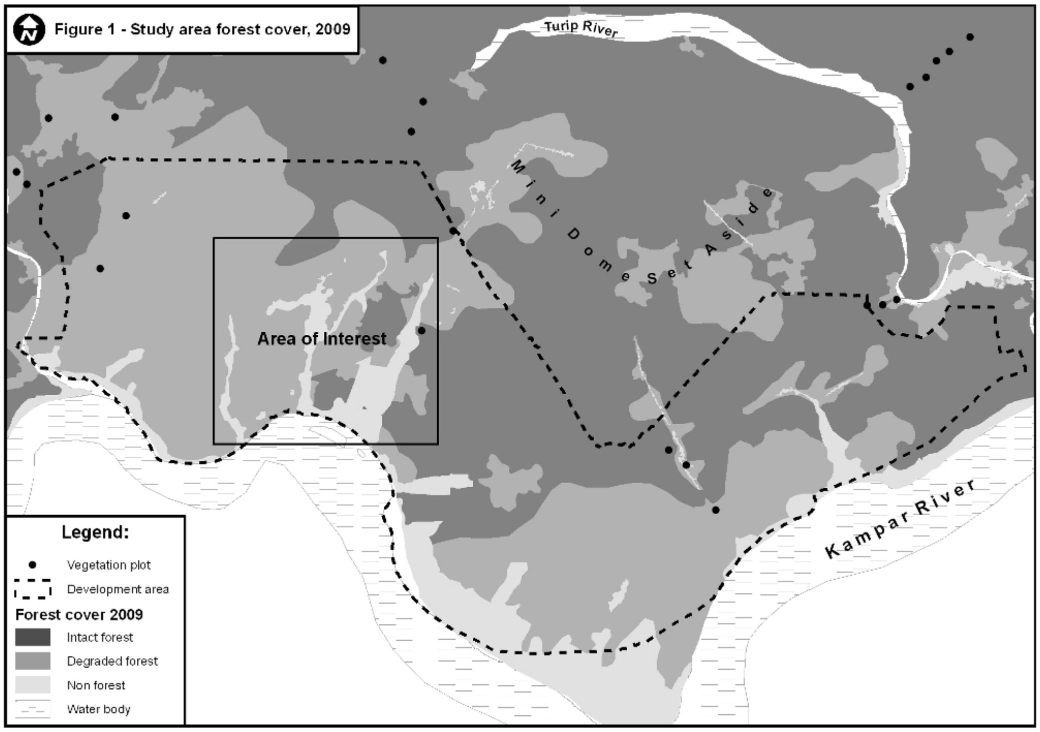

Figure 1.

For the period 2005-09 an estimate of the mean rate of change in biomass was made from two types of change. For areas that changed from intact to damaged forest and damaged to non-forest (Table 1 a): the product of hectares and plot-scale biomass difference between the cover types in 2004 (Table 1b). For remaining areas that did not change cover type, the product of hectares (Table 1a) and plot-scale biomass change (Table 1b). The estimated loss in biomass totals 1.2 M t CO_2 or 7-8 t CO_2 ha^{-1} yr^{-1}.

Table 1. Change in Natural Vegetation Cover

(a) Landscape Cover: hectare (% of study area)	1995	2005	2009
Intact	22,894 (98)	14,358 (62)	10,559 (45)
Degraded	30 (0)	7,970 (34)	10,970 (47)
Non-forest	382 (2)	978 (4)	1,777 (8)

(b) Sample Plots: No.of plot (stem m3 /ha) biomass t CO2 /ha	2004	2011
Intact, distant*	5 (195) 215	5 (192) 211
Intact, near**	2 (180) 198	2 (144) 158
Degraded	8 (147) 162	7 (67) 74
Non-forest	-	1 (0) 11

* distant >500 m of degraded forest; ** near <200 m of degraded forest

Table 2. Factors Related to Forest Decline

Proximity to logged gap (m)	No. of plots	Forest condition 2004	Forest condition 2011	Stem vol ume loss 04-11 (%)	Water ta ble depth 2011 (m)	Apparent cause of forest decline
500	3	Intact	Intact	1	0.1	none
200	2	Intact	(less) Intact	13	flooded	edge effect
30	3	Intact	(less) Intact	24	0	edge effect
0	1	Logged	Degraded	49	0	canopy gap formed
0	5	Logged	v. Degraded	76	0.5	ditto incld drainage
0	1	Logged	Non forest	99	flooded	wild fire

Topographic Changes

Figure 2 shows DEM of the 2003 terrain and the 2010 terrain for part of the study area. Most of the terrain lost elevation over 7 years. This has been largest close to deforested drains and least where forested, implicating soil subsidence. Intact forest, e.g. the set-aside peat mini-dome, changed least in elevation. Elevation loss over the 16,000 ha area resurveyed in 2010 averaged 0.19 m: 1,900 m^3 ha^{-1}. Applying the soil factors given in Methods, soil subsidence emission is estimated to be CO_2 19-27 t ha^{-1} yr^{-1}.

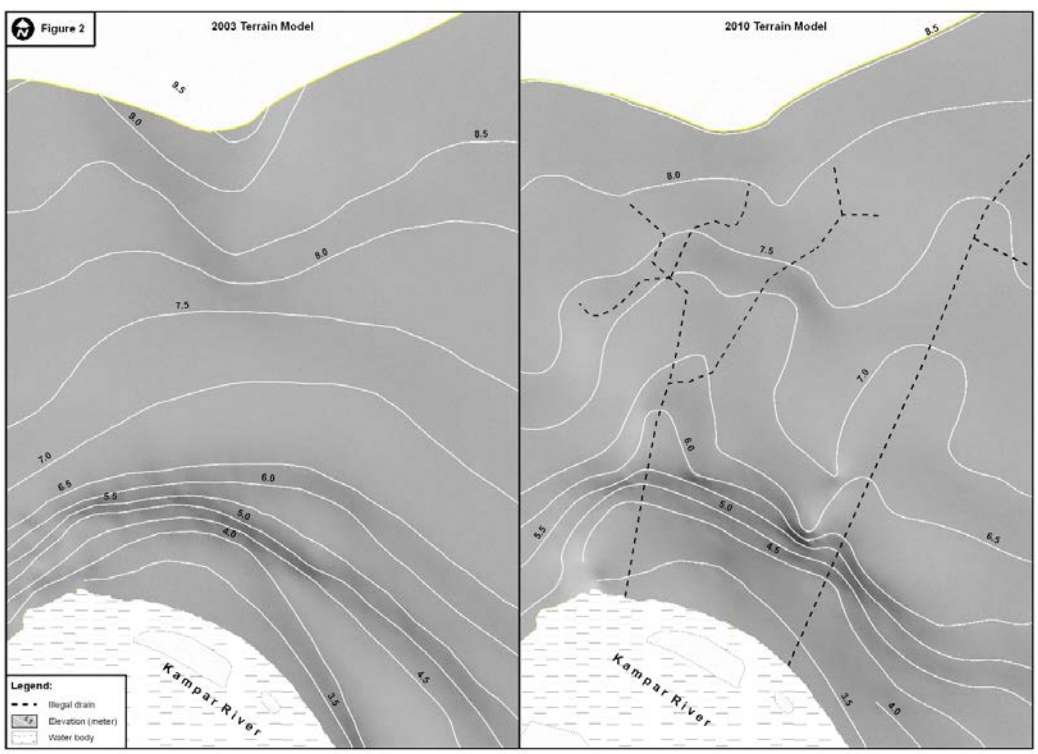

Figure 2.

DISCUSSION

By 2010 the study area landscape had become incised and distorted by deep subsidence valleys. This was not an intact raised dome with a gently undulating surface that water flow lines could follow and keep soils saturated most of the time. We suggest that by 2010 non development alone was no longer a realistic option to conserve soil carbon in its original state, and therefore possibly to conserve the natural ecosystem. Subsidence was set to continue until the sinking valleys eventually became permanently flooded.

Widespread forest deterioration was still occurring in 2011, years after and at distance from the original illegally logged gaps, due apparently to edge effects, e.g. exposure to wind, drying and lowered water tables. Residual forest set-asides such as the dome crest outside the resurveyed study area have been monitored since late 2010 when all drains were closed with weirs. To date no reduction in forest biomass loss has been observed.

It is important to know the carbon footprint of peatland development. To do so reliably requires that soil and biomass stock changes be assessed at broad landscape scale and over very long horizons. This small and brief study can only be indicative. It tentatively estimates CO_2 loss at 25-30 t ha^{-1} yr^{-1} for the period, in this case seven years, after most of the illegal logging had moved on and before formal development had commenced.

ACKNOWLEDGEMENTS

Many Riau Fiber technical and field staff helped to provide the data. Tony Greer provided the 3-D model used to analyze terrain elevation change.

REFERENCES

Bathgate, J., Greer, T., Rachmady R. (2011). Carbon, conservation and agricultural development – the coastal peatlands of Sumatra, Indonesia. World Agriculture Vol.2 No. 2, 28-35.

Hatano, R., Inoue, T., Yamada, H., Sato, S., Darung, U., Limin, S., Limin, A., June, T., Suwardi, Sumawinata, B., Wijaya, H., Wijonarko, S., Bathgate, J. (2010). Soil greenhouse gases emissions from various land uses in tropical peatlands in Indonesia. Proceedings of Palangkaraya International Symposium Workshop on Tropical Peat 47-55.

Verchot, L.V., Petkova, E., Obidzinski, K., Atmadja, S., Yuliani, E.L., Dermawan, A., Murdiyarso, D. and Amira, S. (2010). Reducing forestry emissions in Indonesia, 11p. Center for International Forestry Research, Bogor, Indonesia.